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Anton Paar

MCR

The Modular Compact Rheometer Series

::: Intelligence in Rheometry



MCR: Your future-proof rheometer.



MCR rheometers offer you one thing first and foremost: An open range of possibilities.

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Which features are available for easy, reliable MCR operation?

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How do the synchronous EC motor's capacities work for you?

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Look forward to your future applications…

MCR: The Modular Compact Rheometer Series

Modular.

MCR rheometry builds on your applications.

Whatever your rheological requirements are and will be in the future – MCR rheometers are efficiently and comfortably adapted to meet your needs. The intuitive application software and patented features like Toolmaster™, an automatic tool recognition and configuration system, make sure of this.

Changing a cone-plate for a concentric-cylinder measuring system is just as easy as integrating a new temperature device or extending your rheometer's testing capabilities with a wide range of application-specific accessories.

Compact.

MCR rheometry builds on your working day.

The space-saving MCR rheometers are designed with a specific focus on ease-of-use, with all components incorporated into one simply installed unit that easily fits on a standard laboratory table.

'Compact' use of your time is guaranteed: The patented TruGap™ system for automatic gap control, the T-Ready™ feature for controlling the actual sample temperature, and of course the speed and precision of the dynamic EC motor itself – these and other MCR characteristics ensure efficient rheological operation.

Rheometer.

MCR rheometry builds on technological innovation.

Benefit from rheological highlights such as the air-bearing-supported, synchronous EC motor, the dynamic TruRate™ sample-adaptive motor controller, the patented normal force sensor integrated in the air bearing, the Piezo Axial Actuator, TruStrain™ real-time position control, continuously improved electronics and numerous other features that ensure the MCR series' world-renowned rheological peak performance.

Anton Paar's Modular Compact Rheometer series: From routine quality control applications to high-end research & development.





Patented Features for Comfort and Efficiency



Automatic recognition of measuring and environmental systems: Toolmaster™

The MCR's modular concept builds on the simple exchange of measuring systems and environmental systems. This exchange basically organizes itself in a very short time – as Toolmaster™ (US Patent 7,275,419) automatically does the work for you, without any selections in the software.

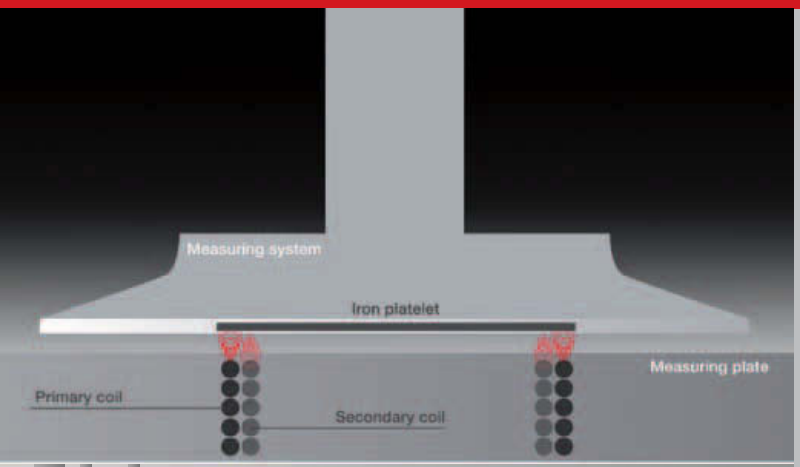
Toolmaster™ is the only completely automatic tool recognition and configuration system for rheology. It recognizes measuring and environmental systems as soon as these are connected to the rheometer. Transponder chips in each accessory's control cable and in the measuring system contain all relevant data, such as truncation, diameter, cone angle and serial number, and automatically transfer these to the application software. Error-free documentation and perfect traceability (21CFR Part11 compliance) are guaranteed.

Easy fitting of measuring systems: QuickConnect

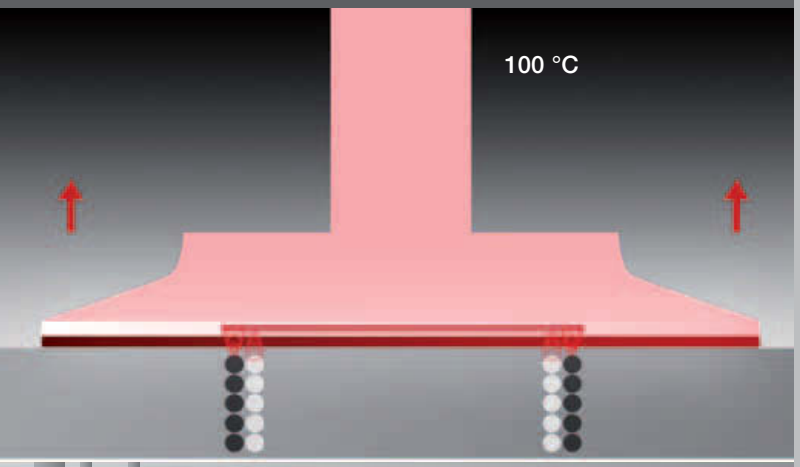
QuickConnect additionally offers you mechanical ease-of-use: The quick-fitting coupling allows one-hand connection of the measuring systems and ensures fast, convenient system changes without the use of a screwing mechanism.

Intuitive control of your device: MCR color display

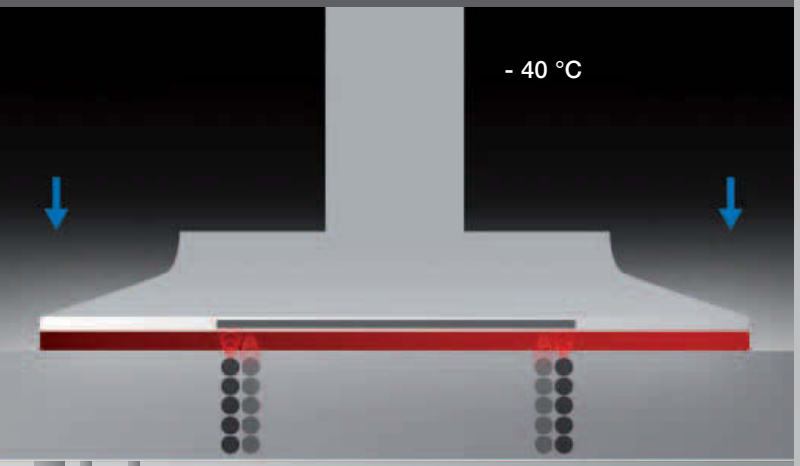
With the MCR series' color display you can manage the complete sample preparation procedure directly at the instrument. The softkeys under the screen offer you the same functionality as a touchscreen, but without the risk of damaging or contaminating the screen in harsh working environments. Physical properties such as normal force, temperature and gap are displayed in a clearly arranged, accessible fashion.



- Primary coil produces magnetic field
- Iron platelet induces voltage in secondary coil
- Gap is measured and adjusted over induced voltage



- Extension of measuring system due to heating - TruGap™ adjusts



- Shrinkage of measuring system due to cooling - TruGap™ adjusts

Permanent control of the measuring gap: TruGap™

Errors in gap size directly influence the accuracy of results in parallel-plate and cone-plate measurements. Precise measuring gap setting is therefore required to accurately measure rheological properties.

In rheological tests with significant temperature changes, like temperature sweeps, the gap size increases or decreases due to thermal expansion or contraction of the measuring system. This previously called for regular zero-gap setting at test temperature and calibrations of the Automatic Gap Control (AGC).

The patented TruGap™ system (US Patent 6,499,336) fully replaces these procedures: The gap is directly measured and precisely adjusted to the desired position independently of the temperature and thermal expansion. One single zero-gap setting suffices. Flawless documentation and complete traceability of the actual measuring gap is guaranteed.

TruGap™ measuring systems are based on a magnetic induction principle. Two coils are embedded in a magnetic core in the bottom plate. An AC current flows through the primary coil, which induces a voltage in the secondary coil since the circuit is closed by a magnetic disc in the upper measuring plate. Based on this voltage, the gap size is consistently measured and adjusted.

Time-saving temperature certainty: T-Ready™

Rheological measurements are strongly influenced by temperature. Therefore, in addition to accurate temperature control, knowledge about the sample temperature equilibration is essential. The new T-Ready™ feature employs TruGap™ functionality to precisely determine when the desired sample temperature has been reached. Unnecessarily extended waiting times before tests are eliminated: T-Ready™ gives a green light or automatically starts the test as soon as the desired sample temperature is reached.

The Key to Accuracy
The EC Motor Technology

The air-bearing-supported synchronous EC motor (also called DC motor) is the key component of the MCR rheometer series.

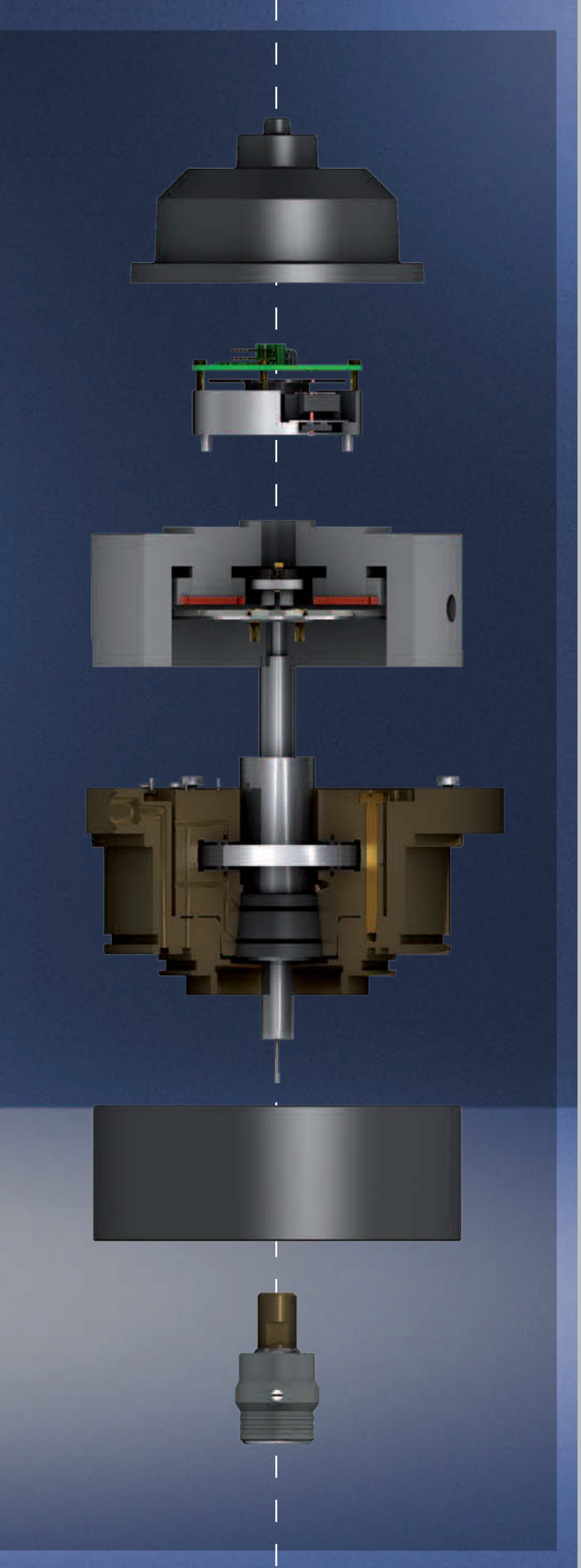
Whether you perform zero-shear viscosity determinations of low-viscosity polymer solutions or measure highly viscous magnetorheological fluids at high shear rates and strains: The EC (Electrically Commutated) motor of the MCR series ensures accuracy across a wide viscosity range – from solids to liquids with viscosities lower than water.

The rotor of the EC motor drive is equipped with permanent magnets. In the stator, coils with opposite polarity produce magnetic poles. The magnets in the rotor and the stator coils attract each other, so that a rotating flux of current in the coil windings produces a frictionless synchronous movement of the rotor.

The torque of the motor is set and measured via the input current to the stator coils. Due to its unique design the EC motor features a linear relation between the torque and the input current to the stator coil, which is advantageous for precise torque control and measurement. These and other motor characteristics considerably benefit your rheological measurements.

Motor characteristics	Your rheological advantage
Instantaneous buildup of magnetic field, no magnetic induction	Fast response times for step rate and strain tests
No eddy current and heat production in motor	Permanent torque values up to 300 mNm
Linear relationship between electromagnetic torque and stator current, one single motor constant	Control and resolution of lowest speeds, deflection angles and torques, TruStrain™
Known constant magnetic field allows motor-controlled blocking	“Trimlock”: Motor-controlled blocking during sample trimming





The optical encoder

The high-resolution optical encoder based on data oversampling technology enables the measurement and control of angular deflections down to 100 nanorad. Combined with TruStrain™ (see next page) this provides the basis for comprehensive studies of samples with weak structures.

The speed of completely digital control

The use of the most recent processor technology in the MCR series increases the speed of data processing and increases the efficiency of transient tests. Due to the additional memory, important signals such as the torque and deflection angle are recorded and processed with higher signal density.

Anton Paar builds on a long-standing working experience with Digital Signal Processing (DSP) – with the MCR series being the first rheometers ever based on this technology. As a result of constant optimization, MCR rheometers are now also controlled with digital current sources. The low fluctuation and high performance of these sources further increases the accuracy of MCR torque measurement and control.

The air bearing

Two air bearings support the motor: A radial air bearing centers and stabilizes the shaft and the axial air bearing holds the weight of the rotating parts.
This established air bearing technology is independent of external influences and therefore applicable without further electronic control.

Continuously optimized for rigidity, drift stability and robustness, the MCR rheometers' air bearing technology together with improved torque scanning enables low-torque measurements down to a minimum of 2 nNm.

The patented normal force sensor

The high sensitivity and increased sampling rate of the patented normal force sensor (US Patent 6,167,752) integrated in the air bearing enables normal force measurements during transient and steady-state tests as well as static normal force measurements, which are used for gap control and DMTA, tack or penetration tests.
The sensor employs an electric capacity method, precisely converting extremely small deflections in the air bearing into the according normal force. Instead of enforcing additional travel, the natural movement already present in the air bearing is used to measure the normal force.
The advantage of the sensor's location in the air bearing: Normal force measurements are available for all temperature devices and application-specific accessories. Whatever your application, the normal force sensor is always immediately functional.

Intelligent Design

Space to work: The housing

Ergonomics, functionality and durability were the central design goals of the compact MCR housing. All mechanical and electrical control components are incorporated into one single, simply installed unit that easily fits on a standard laboratory table. You are given sufficient space for sample loading, trimming and further preparation.

The mechanical self-alignment of all accessories ensures comfortable work with the modular MCR system. In addition, customized housing solutions are available, e.g. for adaptation to a confocal microscope.

Maximum rigidity: The frame

Due to the MCR rheometers' rigidity, changes in environmental temperature cannot influence the results of long-term tests. The new MCR series are built with a steel frame for optimized mechanical and thermal stability. In addition to the low compliance of the steel itself, the Piezo Axial Actuator (PAA) actively compensates the residual compliance.

Compliance in check: The Piezo Axial Actuator

The Piezo Axial Actuator enables nanometer-scale gap size changes by three Piezo elements in the rheometer's bottom flange. This system provides additional measuring gap constancy – an especially vital feature for long-term measurements at low torques – and actively compensates the entire system's axial compliance in transient tests.

Connections

The modular concept of the MCR series is well reflected by the instrument's interfaces. The result: More options for flexible work.

- USB interface for direct communication with computer
- Ethernet interface for direct or network communication
- 4 analog interfaces for triggering external devices
- 3 auxiliary inputs for reading external devices
- Thermocouple interface for temperature reading
- Pt 100 interface for temperature reading





Intelligent Control

TruRate™

The MCR series' TruRate™ sample-adaptive controller intelligently adapts to the sample conditions at hand. Without prior information on the sample, and without any pre-testing, sample strains, shear rates or stresses are precisely controlled. The desired settings are achieved in minimum time; no additional software selections are required.

TruRate™ swiftly adjusts to the desired shear rate step or step in strain without overshoots – for accurate investigations of all kinds of samples.

TruStrain™

Strain-controlled oscillatory tests with common stress-controlled (CS) rheometers usually require a "guessing game", including several oscillation cycles and subsequent adjustments, to reach the desired strain amplitude. TruStrain™ takes a different approach: Instead of amplitude control, it employs real-time position control based on the Direct Strain Oscillation (DSO) method. This ensures more efficiency and drift-free measurements at smallest torques and strains.

TruStrain™ adjusts to the desired strain directly on the sine wave, and the measuring system directly follows this required change in strain during each individual oscillation cycle. This means you are able to preset and control precisely sine-shaped strains both within the linear viscoelastic (destruction-free) range as well as in Large Amplitude Oscillatory Shear (LAOS) conditions. For close observation of intercycle processes, the application software optionally displays oscillatory waveforms and Lissajous diagrams.

TruStrain™ is especially valuable for oscillatory measurements on complex fluids such as gels, emulsions, suspensions, colloids, surfactant solutions, lubricating grease and foams.

Sample torque calculated by knowing inertia

The electric motor torque, the forcing frequency (set values) and the total moment of inertia or, alternatively, the deflection angle and the phase shift between the electric motor torque and the angle response (measured values), can be used to determine all rheological parameters.

Modular Temperature Control…

Anton Paar offers a wide range of modular temperature devices tailored to specific rheological requirements – from -150 °C to 1000 °C, from low-viscosity liquids to highly elastic solids, from traditional rheological tests to DMTA measurements. All systems are easily exchanged within the MCR series and ensure virtually gradient-free temperature control for all applications. Make your first selection here.



C-PTD 200	C-ETD 200/300	PTD 200	CTD 180
-30 °C to 200 °C	RT* to 200/300 °C	-40 °C to 200 °C	-20 °C to 180 °C
▸ Cylinder ▸ Conduction ▸ Patented Anton Paar technology (US Patent 6,240,770)	▸ Cylinder ▸ Conduction	▸ CP/PP ▸ Conduction ▸ Convection ▸ Radiation ▸ Patented Anton Paar technology for Peltier-controlled hood (US Patent 6,571,610)	▸ CP/PP/DMTA solid fixtures ▸ Convection ▸ Radiation
Low-viscosity liquids			
Viscoelastic liquids			
		Melts	
		Paste-like materials	
Gel-like materials			
		Soft solids	
		Reactive systems	
			Solids
▸ Fully incorporated, truly Peltier-temperature-controlled system ▸ High heating and cooling rates ▸ No vertical temperature gradient in sample due to patented thermal transfer system	▸ Especially suited for measurements of low-viscosity samples at high temperatures ▸ High heating rates ▸ Ideal for use with pressure cell	▸ Fully incorporated, truly Peltier-temperature-controlled system ▸ TruGap™ support ▸ T-Ready™ feature ▸ Sliding rail for easy access and sample trimming ▸ Evaporation Blocker: prevents loss of volatile solvents ▸ Temperature-isolated hood (hand-warm for safe use) ▸ Isolated hood according to EN61010-1:2001	▸ Truly Peltier-temperature-controlled convection oven ▸ TruGap™ support ▸ T-Ready™ feature ▸ DigitalEye CCD camera function ▸ Modular configuration (DMTA torsion/tension, Photo DMTA/UV, reaction kinetics, SER extensional rheology) ▸ Temperature-isolated jacket (hand-warm for safe use) ▸ Actively cooled jacket and exhaust according to EN61010-1:2001

* Room temperature

…from –150 °C to 1000 °C

Anton Paar's temperature devices are based on the physical principles of conduction, convection and radiation.

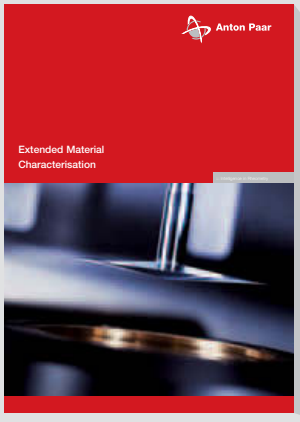
ETD 400	CTD 450	CTD 600	CTD 1000
-130 °C to 400 °C	-130 °C to 450 °C	-150 °C to 600 °C	-150 °C to 1000 °C
▸ CP/PP ▸ Conduction ▸ Convection ▸ Radiation	▸ CP/PP/DMTA solid fixtures ▸ Convection ▸ Radiation	▸ CP/PP/DMTA solid fixtures ▸ Convection ▸ Radiation	▸ CC/PP/DMTA solid fixtures ▸ Cylinder ▸ Convection ▸ Radiation
	Solids		
▸ Ideal for measurements of tablets, granules and powders ▸ Sliding rail for easy access and sample trimming ▸ Temperature-isolated hood (hand-warm for safe use) ▸ Isolated hood according to EN61010-1:2001 ▸ High heating rates ▸ Cooling by compressed air, water or liquid nitrogen	▸ TruGap™ support ▸ T-Ready™ feature ▸ Modular configuration (DMTA torsion/tension, Photo DMTA/ UV, reaction kinetics, SER extensional rheology) ▸ Digital Eye CCD camera function ▸ Pt 100 signal reflects true sample temperature ▸ Temperature-isolated jacket (hand-warm for safe use) ▸ Actively cooled jacket and exhaust according to EN61010-1:2001 ▸ Evaporation unit actively controls continuous flow of liquid nitrogen: most stable temperature signal at low temperatures	▸ Modular configuration (DMTA torsion/tension, Photo DMTA/ UV, reaction kinetics, SER extensional viscosity) ▸ Pt 100 signal reflects true sample temperature ▸ Temperature-isolated jacket (hand-warm for safe use) ▸ Actively cooled jacket according to EN61010-1:2001 ▸ Evaporation unit actively controls continuous flow of liquid nitrogen: most stable temperature signal for low-temperature applications	▸ Most suitable for measurements of glass and metal melts ▸ Thermocouple signal reflects true sample temperature ▸ Temperature-isolated jacket (hand-warm for safe use) ▸ Actively cooled jacket according to EN61010-1:2001 ▸ Evaporation unit actively controls continuous flow of liquid nitrogen: most stable temperature signal for low-temperature applications

Build on Your Rheometer: Application-specific Accessories

Obtain additional structure information, set additional parameters or employ the rheometer's functionality for further material characterization: This wide range of application-specific accessories is easily integrated into your MCR rheometer.







Additional Parameter Setting

Employ these accessories to set additional parameters together with the temperature for rheological tests.

Pressure Cell

Rheology under pressure is used to simulate process conditions, to measure the sample's pressure-dependence or to prevent sample evaporation above the boiling point.

UV Curing System

The UV Curing System enables you to investigate UV-initiated curing reactions, following materials' development from their original to their fully cured state.

Immobilization Cell

The patented Immobilization Cell (IMC) (US 6,098,450 (A)) is used to investigate the immobilization kinetics and water retention of paper coatings.

Magneto-Rheological Device

With the Magneto-Rheological Device (MRD) you can analyze the influence of a magnetic field on magnetorheological fluids (MRF) and ferrofluids.

Electro-Rheological Device

The Electro-Rheological Device (ERD) is used to research the influence of an electric field on electrorheological fluids (ERF).

Structure Analysis

Gather sample structure information by combining these optical and dielectric methods with rheology.

Rheo-Microscope
A combination with light microscopy allows the visualization of the influence of shear and deformation forces on the sample's microstructure. Options for polarized, fluorescent and UV microscopy are available.

Rheo-SALS
A combination with small-angle light scattering allows the investigation of shear-dependent microstructure changes or crystallization by scattering pattern analysis.

Dynamic Optical Rheo-Analyzer (DORA)
For measurements of flow birefringence and flow dichroism during rheological tests.

Rheo-SAXS
A combination with small-angle X-ray scattering enables investigations of shear-induced nanostructure changes.

Rheo-SANS
A combination with small-angle neutron scattering facilitates nanostructure analysis.

Particle Image Velocimetry (PIV)
For visualization of flow fields during rheological tests by following tracking particles.

Dielectro-Rheological Device
The Dielectro-Rheological Device enables investigations of the influence of mechanical deformation on samples' conductivity, capacity and permittivity.

Extended Material Characterization

These accessories transfer the MCR rheometer's measuring capabilities into other material characterization applications.

Extensional Rheology
Extensional fixtures turn MCR rheometers into extensional rheology platforms.

Dynamic Mechanical Thermal Analysis (DMTA)
DMTA fixtures for solids, films and fibers allow material characterization in torsion and tension over a large temperature range.

Starch Rheology
The Starch Rheology System enables rheological investigations on starch gelation processes.

Large-particle Rheology
Accessories such as the Ball Measuring System and the Building Material Cell are used to measure the flow properties of samples with very large particles such as building materials and foodstuff.

Interfacial Rheology
The Interfacial Rheology System enables investigations of interfacial films at the liquid/gas and liquid/liquid interface.

Tribology
The Tribology System turns your MCR rheometer into a fully functional tribometer based on the ball-on-three-plates principle, or a testing platform for rolling-element bearings.

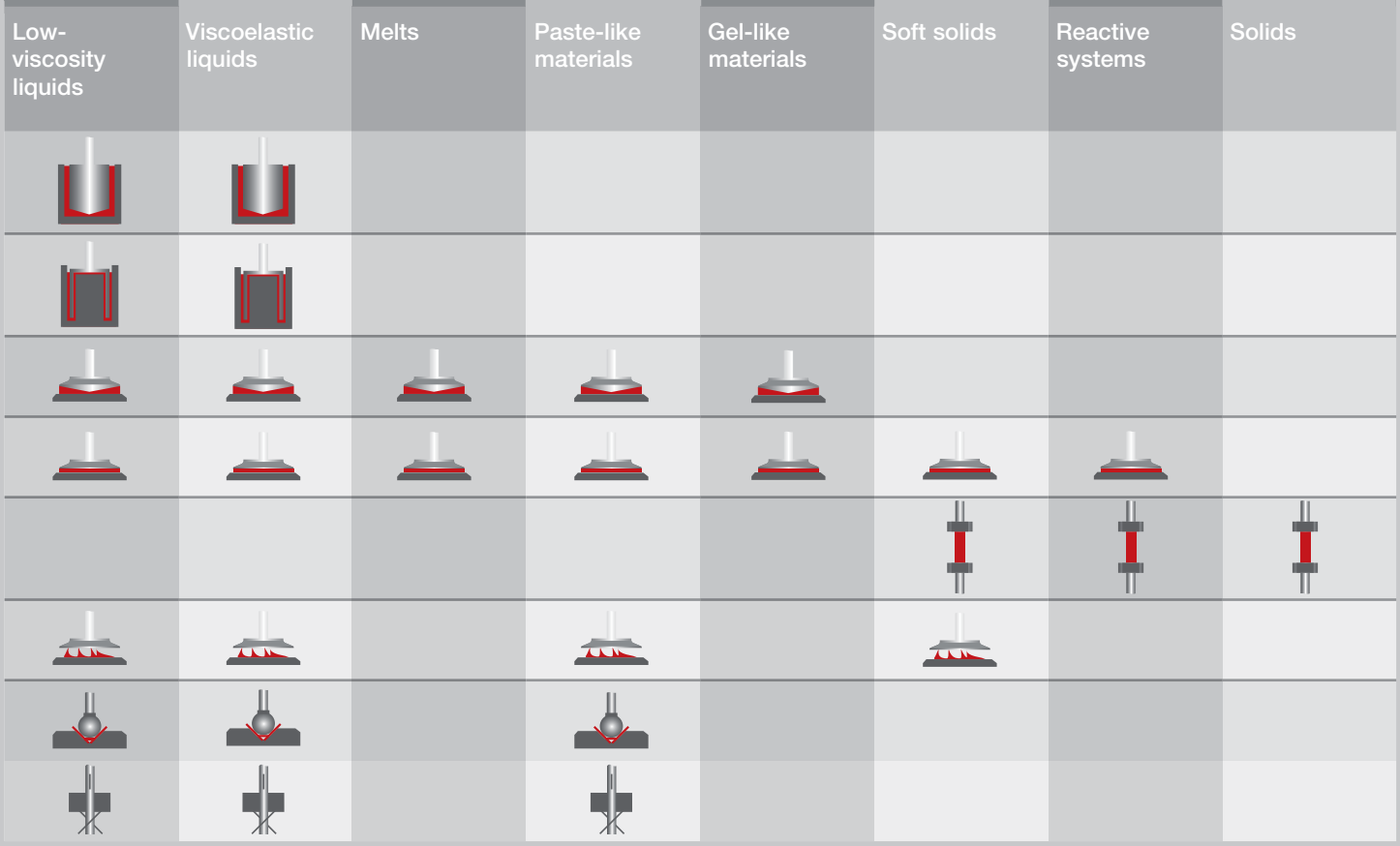
Powder Rheology
The Powder Rheology System allows shear-rheological tests on powders and granulates.

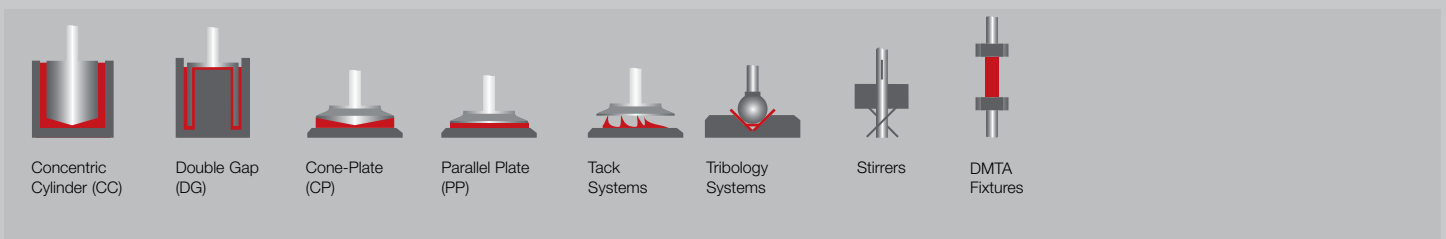
The Advantage of Diversity
MCR Measuring Systems

The MCR measuring systems can be used with all temperature devices and are interchangeable within their category of accessories. For example, a PP 25 parallel-plate measuring system can be used in all according LTD, PTD, ETD or CTD systems.

All geometry dimensions, safety limitations and calibration constants are saved in the Toolmaster™ chip located in the coupling of every measuring system. Made from diverse materials and featuring different surfaces and dimensions, all measuring systems are optimized regarding compliance, thermal expansion and thermal conductivity.







Measuring System Variants

With hundreds and hundreds of measuring systems, and their efficient combination with a wide range of environmental systems, there is barely any application that cannot be covered by an Anton Paar MCR rheometer.

The following nomenclature gives you an overview of available measuring system variants and how they are denoted.

Prefix

- **D** ::: Disposable plate
- **DC** ::: Disposable cup
- **FDD** ::: Fixture for disp. dishes
- **DD** ::: Disposable dish
- **CAP** ::: Cap plate

Shaft

- **PR** ::: Pressure
- **Z** ::: Zerodur shaft
- **PE** ::: PEEK shaft
- **ERD** ::: Electro-Rheological Device
- **MRD** ::: Magneto-Rheological Device
- **TG** ::: TruGap™
- **DI** ::: Dielectro-Rheological Device
- **CR** ::: Counter-rotating

Material

- **SS** ::: Stainless steel
- **TI** ::: Titanium
- **HA** ::: Hastelloy
- **INV** ::: Invar
- **PC** ::: Polycarbonate
- **AL** ::: Aluminum
- **GL** ::: Glass
- **INC** ::: Inconel
- **CA** ::: Carbon

D – P P – 20 – P R / S S / S

Dimension in mm

Type

- **CC** ::: Concentric cylinder
- **DG** ::: Double gap
- **ST** ::: Stirrer
- **PP** ::: Parallel plate
- **CP** ::: Cone-plate
- **ME** ::: Mooney Ewart
- **BM** ::: Ball measuring system
- **PPR** ::: Plate-plate ring
- **CPR** ::: Cone-plate ring
- **SRF** ::: Solid rectangular fixture
- **SCF** ::: Solid circular fixture
- **UXF** ::: Universal extensional fixture
- **SER** ::: Sentmanat ext. rheometer
- **BIC** ::: Bi-cone
- **BC** ::: Tribology system
- **TG** ::: Twin gap
- **MD** ::: Measuring dish

Surface

- **S** ::: Sandblasted
- **P2** ::: Profile 2 (PP), 0.5 mm
- **P3** ::: Profile 3 (PP), 0.1 mm
- **P6** ::: Profile 6 (bob, beaker), 1.5 x 0.5 mm
- **P7** ::: Profile 7 (bob, beaker), 2.3 x 0.5 mm
- **PX** ::: Profile special
- **HL** ::: Helical profile left handed
- **HR** ::: Helical profile right handed
- **HX** ::: Helical profile special
- **CX** ::: Coated

Is an Instrument with $n_{min} = 10^{-8}$ rpm Better than with $n_{min} = 10^{-7}$ rpm?

The technical specifications classify a measuring instrument. But if these specifications do not include spreads and error limits, they are not indicative of a measuring instrument's performance. Therefore, specifications are only conclusive if they include the conditions under which they were defined.

In this regard, the following distinction is essential:

1. The specification is valid under certain measurement conditions.
   - After a single verification, this statement is already proven.
2. The specification is always valid, i.e. under all measuring conditions.
   - As it is impossible to perform an infinite number of measurements, this statement essentially cannot be proven applying stringent logical criticism. A single case of opposite truth already disproves the statement.

The user can verify specifications by practical testing, a rheological measurement. To this end, however, all influencing factors, e.g. the ambient temperature, the averaging period for measuring points, installation conditions or the used standard material need to be considered.

The physical property rotational speed is used as an example to illustrate the influence of the averaging time on the measurement result measured in air:

At 10^{-7} rpm, a measuring system fully turns on its own axis over the course of 19 years. No user waits this long for a measuring point. Shorter measuring times, i.e. averaging times, are used to determine the measurement results, which in turn effect errors of different magnitude. Practically speaking, however, the signal detected over 10 seconds of averaging time cannot be used (Fig. 1) and does not meet the user's expectations.

The example also shows that an extended averaging time of 15 min, based on a maximum permissible standard deviation of 5 %, for example, still facilitates a rotational speed of 10^{-7} rpm (Fig. 2) or even lower rotational speeds. Bear in mind, however, that each measuring range extension of a decade down to lower rotational speeds triples the magnitude of the error.

Traceability and transparency

Specifications from Anton Paar are traceable, as they include information on the environmental and measurement conditions under which they were defined. Anton Paar provides you with this information.

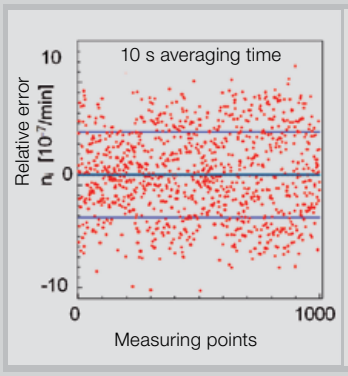


Fig. 1

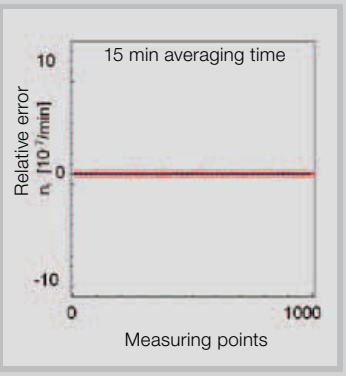


Fig. 2

Rotational speed	Averaging time for a measuring point	Covered angle	Standard deviation
n= 10^{-7} rpm	1 day	0.052° = 0.905 mrad	0.06 %
n= 10^{-7} rpm	15 min	0.00060° = 10.5 µrad	5 %
n= 10^{-7} rpm	10 sec	0.000006° = 0.105 µrad	400 %

Specifications

	Unit	MCR 52	MCR 102	MCR 302	MCR 502
Bearing	-	Ball	Air	Air	Air
EC motor (brushless DC) with high-resolution optical encoder	-	✓	✓	✓	✓
Permanent torque (60 min), no signal drift	-	✓	✓	✓	✓
EC mode (controlled shear rate and shear stress)		✓	✓	✓	✓
Maximum torque	mNm	200	200	200	230
Minimum torque, rotation	nNm	250 µNm	50	10	10
Minimum torque, oscillation	nNm	-	10	2	2
Torque resolution	nNm	100	0.5	0.1	0.1
Angular deflection, set value	µrad	1 to ∞	1 to ∞	0.1 to ∞	0.1 to ∞
Angular deflection, resolution	nrad	10	10	10	10
Step rate, time constant	ms	-	5	5	5
Step strain, time constant	ms	-	10	10	10
Step time (rate, strain), 99 % of set value (all samples)	ms	-	30	30	30
Minimum angular velocity [1]	rad/s	10^{-4}	10^{-8}	10^{-9}	10^{-9}
Maximum angular velocity	rad/s	314	314	314	314
Minimum angular frequency [2]	rad/s	10^{-3}	10^{-7} [3]	10^{-7} [3]	10^{-7} [3]
Maximum angular frequency	rad/s	628	628	628	628
Normal force range	N	-	0.01 to 50	0.005 to 50	0.005 to 50
Normal force resolution	mN	-	1	0.5	0.5
Dimensions	mm	678 x 444 x 586	678 x 444 x 586	678 x 444 x 586	753 x 444 x 586
Weight	kg	42	42	42	47
Toolmaster™, measuring system	-	✓	✓	✓	✓
Toolmaster™, measuring cell	-	✓	✓	✓	✓
QuickConnect for measuring systems, screwless	-	✓	✓	✓	✓
Electronic trimlock for the measuring system	-	✓	✓	✓	✓
Digital Eye, Software video option and camera	-	○	○	○	○
Virtually gradient-free (horizontal, vertical) temperature control	-	✓	✓	✓	✓
CoolPeltier™, Peltier system with built-in cooling option requiring no additional accessories for counter-cooling	°C	-5 to 200	-5 to 200	-5 to 200	-5 to 200
Peltier-based convection oven, does not require LN_2 for cooling	°C	-20 to 180	-20 to 180	-20 to 180	-20 to 180
Actively Peltier-controlled hood, Peltier technology	°C	-40 to 200	-40 to 200	-40 to 200	-40 to 200
Concentric-cylinder Peltier temperature control	°C	-30 to 200	-30 to 200	-30 to 200	-30 to 200
Maximum temperature range	°C	-150 to 1000	-150 to 1000	-150 to 1000	-150 to 1000
Automatic gap control/setting, AGC/AGS	-	✓	✓	✓	✓
TruGap™ for in-place measurement and control of the gap	-	✗	✓	✓	✓
T-Ready™	-	✗	✓	✓	✓
Direct strain, amplitude controller	-	✓	✓	✓	✓
Direct stress, amplitude controller	-	✓	✓	✓	✓
TruRate™	-	○	○	✓	✓
TruStrain™	-	✗	○	✓	✓
Normal force and velocity profiles, tack, squeeze	-	✗	○	✓	✓
Raw data (LAOS, waveform, ...)	-	✗	○	○	✓
Piezo Axial Actuator (PAA)	-	✗	✗	✗	○

1) Depending on measuring point duration and sampling time, practically any value is achieved (see page 22)
2) Set frequencies below 10^{-4} rad/s are of no practical relevance due to the measuring point duration > 1 day
3) Theoretical value (duration per cycle = 2 years)

Legend: ○ optional



Photos: Croce & Wir

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06/11 C92IP001EN-B

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